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PAN-PACIFIC SCIENCE MEETING
HONOLULU, FRIDAY, APRIL 7, 1933

Chairman: I was asked to give a short talk on the rat proofing of houses during the dinner which was scheduled for last Friday. At the same time I was to show some models to illustrate the methods used. The principal speaker of the evening, however, could not appear, and the dinner was cancelled. This dinner talk that we were to have last week has now grown to quite an extensive program. The whole evening of this scientific dinner meeting is to be given to rats. This is rather appropriate. Of you had one rat last week you might expect this week to have six of seven. They do not neglect their opportunity to increase and multiply. Last week we had one little rat subject; this week we have six rather big and important rat subjects. Although I helped Miss Satterthwaite get up this program, I am going to say that I think it is a very good one, and that the speakers could hardly be duplicated anywhere.

I have here in my hand a rather large and important looking book. It is the proceedings of the Second International and Colonial Congress of the Rat and of Plague, which met in Paris in October 1931. I had something to do with the first conference, which met in 1928. Both of these conferences had delegates from all over the world, and was recognized by many nations. This may impress upon you the fact that the rat is a very serious subject, and by no means a joke, as some people consider it. I think you can safely say that the list of speakers that we have tonight can be compared, in quality, anyway, with the list of speakers that addressed the august international assembly that considered the problem of the rat and his control.

We have Mr. E. H. Bryan, curator of the Bishop Museum; C.E. Pemberton, executive entomologist of the H. S. P. A. Experiment Station known everywhere for what he has done; Dr. F. E. Trotter, president of the Board of Health, Territory of Hawaii, who has had under his hand a real plague problem; Surgeon C. R. Eskey, of the U. S. Public Health Service, who has devoted the last five or six years to research work in plague Control; Mr. B. W. Griffitts, president of Commonwealth Homes, Ltd., a keen enough business man to see the value of our work; and myself, as I have been working on rats and plague for over 35 years that is an endurance record if nothing more.

The first speaker is Mr. Bryan, who will get us started on a proper basis by discussing "The Place of Rats in the Animal Kingdom."

Mr. Bryan: Before talking on what rats do, I will tell you what a rat is. I have brought a chart and a book and a few notes along, which I will try to give you quickly so as to let the principal speakers of the evening have a little more time.

This is Rattus hawaiiensis. (A preserved rat in a glass jar.)

And now, to tell you what a rat is. You are all familiar with the fact that the animal kingdom is divided into two groups, the invertebrates and the vertebrates. The invertebrates consist of ten phyla. The vertebrates only represent part of one phylum, the cordata, but they are larger and more important from the standpoint of man. The rats belong to that group. The vertebrates are the mammals, the monotremes, (these are a primitive form, now only found in Australia), the marsupials, the edentates (the toothless forms, sloths are an example), the undulates (the hooved animals, the cows, etc.), the aquatic mammals (the whale is an example), the sirenians, the cetaceans (including the sea cow), the carnivores (meat eating animals, - the mongoose, spelled with a "u" in India, is one of these), and the rodents (or gnawers, which include the rats -- I will skip over this for a moment), the insectivore (the insect eaters), and the primates (from the lemurs to man).

The rodents are the gnawing animals, usually of small size. Rodents are defined and recognized because of their teeth.I brought a specimen along which I will pass around. The factor to look for is the fact that they have two chisel-like incisor teeth.These grow continuously during life. They start as small teeth when the rat is a baby. There is a gap between these two incisors and the molars and they a r e neither canine teeth nor pre-molars. In some of the group of rodents you have p r e-molars, but they are very much reduced.

The rabbits, which are also rodents, but a very distinct group,also have two pairs of chisel-like teeth in their upper jaw.

The feet have five toes, with sharp little claws growing on ends of the toes.

Rodents are found in practically every part of the w o r l d and they date back to the eocene period. Among the group rodents are the squirrels,the flying squirrel, the chipmunks, the gophers, the prairie dogs, the beavers, the dormice, rats, mice, water rats, hares, etc. You have quite an assembly of these rodents.There are about 40 species, a large and important group.Some are very important economically. We eat hares and rabbits,but a great many of the rodents are destructive and detrimental, and live on plant material which we do not want to share, a n d they also carry disease.

In Hawaii, we have about six kinds of rats and mice. First is the Hawaiian rat, which is noticeably smaller than other rats we have here. For a long time it was thought to be exceedingly scarce, but recently the Health Department and health campaigns have scared up great numbers of these. It was not described till recently, although it has been known for 150 years.Then we have the brown rat, the Rattus norvegicus. Then the black rat, the Rattus rattus, nesting in buildings; the brown rat likes to burrow in the ground. The Rattus alexandrinus isthe white bellied brown rat. It lives in trees to some extent. It likes the pandanus, the cocoa palm.

When Captain Cook came here he reported "a very small mouse." It may have been the Mus m u s c u l u s, which has been abundant here since 1825 anyway. I have a specimen in the Museum, carefully labelled "Mus hawaiiensis." I have no other record of it. It is a nice little mouse, but whether it is supposed to be a new species or not I do not know.

That in brief sums up what rats are and what we have here. I will turn the discussion over to more practical and specialized speakers.

Chairman: Thank you very much. We have so many on the program, I think it a good thing if questions come to your mind that you jot them d o w n and at the end ask questions.

It would be entirely out of place for me to introduce Mr.Pemberton, who is known to all of you for his splendid work.

Mr. Pemberton: I did not realize that Dr. Grubbs had such a large program for me to expound on, "Cost of Rats to Industry, Especially Sugar, and Methods of Control." He notified me by telephone the other day.

I think if I confine my remarks on t h e cost to t h e public through damage done by rats, I would like to confine it to sugar. I know estimates have been made on other crops and I might have had mainland statistics -- all estimates, but we know pretty well what the damage has amounted to in the Islands, and that will be a concrete example.

Prior to 1922, the damage was much greater than since that time because extensive control methods have been developed and carried out continuously since then.

I went to Honokaa in 1922. There was plague there and the rats were doing a great amount of damage. I found that the damage done was typical of that particular region for many years, but according to old timers it was greater before the mongoose was introduced. The damage was great on all the islands and probably on the Island of Kauai also.

The rat will eat the sugar cane stalk very extensively, and when a large colony lives in any field, the number of stalks eaten makes the actual loss of sugar a very large factor. We devoted a lot of time in Honokaa in working out this loss in terms of dollars and cents, or sugar, in order to convince the planters it was worth money to control the rats.

As a rule, the rat confines its feeding to the part of the stalk in which there is the most sugar. If a hole even one inch by one inch is eaten, or even if the rind is broken a little and not touched by a rat again, all about the portion of stalk injured there is considerably less sugar. There is fermentation and souring which amounts to a great deal of loss. We worked in cooperation with the chemist, in order to get a chemical analysis made of certain canes in certain stages, all this on a big scale. We found in general if a stick of cane were chewed by a rat within at least a week before it was cut (it was generally a longer time than that) that stalk will have 1/5 at least less sugar in it than if it had not been bitten or chewed into. So, in addition to the stalks chewed off, the stalks bitten and still standing even showed a loss of sugar.

At Honokaa they were producing about 13,500 tons of sugar annually. We estimated and worked it out -- determined the amount of injured stalks in all fields, and the loss by chemical analysis, in cooperation with the chemists, must be between $100,000 and $200,000 a year. We tried to be conservative. The manager felt the loss was very much greater than this. But they are all very conservative in making estimates, so a $100,000 loss a year on a small plantation like that is a very much greater loss actually, because when the sugar people announce that it is a real loss and can be estimated, it probably means the loss that cannot be estimated brings it up to twice that figure.

There were a number of plantations on Kauai also affected, and others on other islands. This loss goes back of course to the very beginning when the plantations were started. So, altogether, if we determine the loss to all plantations in this territory, it would come to over $500,000 a year. This loss was so great that Honokaa Sugar Company realized that if they could control the rats, without spending $150,000 a year to do it, they might make a paying proposition of the plantation. The crop also is raised under other trying conditions, climatic comditions, rainfall, etc.

We developed with the plantation a method of poisoning the rats. We manufactured it, applied it in fields regularly, like hoeing or irrigating. It became part of the plantation scheme, day after day, year after year. This work developed to such a very large extent over there that practically every field that ever had suffered previously from rat attacks was helped. After it became certain that the application of poison systematically was worth while, they produced cheaper ways of making the poison. Today every field receives poison every year at definite periods. That has been going on since 1923, with the result that instead of 15 to 30 per cent of stalks being damaged, as I found when I visited there, today they claim, and I believe the figures are accurate, that the average number of damaged stalks is only 3 to 5 per cent. And that has come about from that operation alone of poisoning the rats. They have changed the variety of cane they plant, and have made changes in other ways, but today Honokaa is producing 27,000 tons of sugar in 1932, where they produced 13,000 tons in 1922, over practically the same territory. I am counting the Honokaa Sugar Company and

the Pacific Sugar Mill. And one of the items that accounts for this greatly increased yield is the systematic control of rats.

The poisons we use have been made from arsenic, strychnine, etc. A long list of things. If you can make the rats eat it you have solved the problem. The difficulty is preparing bait. I believe Dr. Eskey has been working on that and has done things since arriving here that improve our knowledge. I think he will tell you something about that. He will tell you that a rat given something to eat will take a bite if it contains a little poison or a lot. The thing is to find what the rat will bite. The application of poison in certain amounts in baits is an important point in preparing and making these baits. We used strychnine and mixed it in whole wheat; or barium carbonate made into small cakes. Rats, however, if they get a taste of poison and live, will usually be shy about tasting it again, especially if they are old and wise.

Today I hear arguments about the difference between these poisons and I have thought myself sometimes, now this one is the best -- and after a year or two have changed my mind.

The rats still are a problem,but there has been a tremendous advance in the territory in means of controlling them.I think the big thing is that every rat has a chance to smell and a chance to eat it.If you expose the poison only once or twice a year, during the times in between there is a chance for the rats to propagate.

Dr. Eskey has refined the bait, and will make the control still greater before we finish..

I think I had better not say more because the time is getting shorter.

Chairman: Thank you very much. Plague is only one of the diseases but is the principal disease transmitted by rats. In the older times they had many terrible diseases, but plague was the most dreaded. That is no longer the case, largely due to the study of this disease and to improving methods of living. Plague retreated less than 100 years ago and became less and less for several decades. It reappeared in Hong Kong the last part of the last century.Two years later it was in India, and in the 20 years following some 20 millions died from it.About that time probably, these islands became infected. Since then there have been a few cases of plague in various parts of the territory. Dr.Trotter has had experience for many years in controlling plague. He will speak on "Our Plague Problem."

Dr. Trotter: The chairman has assigned the topic of our plague problem, and before taking that up I would like to review the history of plague in Hawaii.

Plague was first discovered in the person of an employee of Wing Wo Tai Store on December 22, 1899, and there is no question but that the infection had existed in the city previous to the discovery of this case. The last case of plague in Honolulu, was on December 26, 1907. During this interval, the largest number of cases occurred in the city in 1900.

On rural Oahu the first case was reported in 1902 and the last case in July 1907. There were 40 cases on rural Oahu, the majority being confined to the vicinity of Aiea. Of these cases, 31 died.

From Oahu, the disease spread to Maui, being discovered there on February 4, 1900, the last case being reported on February 25, 1900. There were a total of 9 cases,all of which ended fatally.The diagnosis of 4 of these 9 cases was malarial fever; the remaining 5 all suffered

from glandular enlargements of the neck, axilla, or in the groin. In one case glands were sent to Honolulu, and as a result of staining and microscopical examination, pest bacilli were determined.

On the island of Hawaii, the disease was first present in Hilo, cases being reported from Olaa, but fortunately for that island, the disease spread out toward the Hamakua Coast, where it became localized and has remained so for many years.The total number of cases on Hawaii since 1900 has been 139.

On Kauai plague was reported November 25, 1901, and the last case reported was on June 30, 1902, there being a total of 7 cases. No clinical results were ever obtained for these cases, nor any autopsies done; consequently, I doubt exceedingly whether plague ever occurred on Kauai, because the officials of that island, whenever any disease occurred on Oahu, promptly refused to allow cargo or persons to be landed on the island for some time.

On Molokai there is no record of any cases of plague whatever.

On Hawaii, plague measures were promptly instituted and have been carried through all the succeeding years. As I stated before, the infection was confined to the Hamakua District and has not spread in the last twenty years. I think the community has taken the presence of plague in the Hamakua District as a matter of course in these years.

It was not until July 31, 1931, that Dr. Chamberlin, a newcomer at Kula Sanitarium, had a fatal case of a patient who died with what he considered very suspicious signs of plague. Dr.Chamberlin wired to me, and accompanied by Surgeon N. E. Wayson, I flew to Maui, and it was definitely proven that this was a positive case of bubonic plague. Later research and investigation, on Maui,has definitely shown that plague has prevailed on that island since June 1930. I think that Dr. Eskey will bear me out in that there were 8 cases in the neighborhood of Paia in 1930, and I am quite certain that there were additional cases which could not be tied up in any way. Since the first case was found in July 1931, we have had to date 5 human cases and 15 cases of rodent plague. I am passing around a map of the plague-infected area of Maui,so that those present can look at it and note that the infection is confined to the Makawao District. Recently plague-infected rodents have been found within 5 miles by air line of the main port of Kahului. Toward the coast from this is a wet belt. There are two possible ways that the plague can spread by dry areas.

Mr. Swezey: Could I ask a question here? You speak as if it could not spread to the east because it was too wet.Is wetness a limiting factor?

Dr. Trotter: Yes, I think so. I think Dr. Eskey will probably mention it later on.

Following the discovery of this plague case on Maui, the plague campaign was organized and put in effect. That has only been possible through other health organizations, Dr. Eskey, and the Chamber of Commerce of Maui. Dr.Eskey was detailed to make a research study of the matter. He will probably tell you of the campaign and the results reached.Dr.Grubbs and myself are also very much interested. Dr. Grubbs is interested in ships, rat proofing ships.We made a thorough study of wharves and shipping, and Dr. Grubbs instituted a search of arriving vessels, to find out if rats were present.

Now Maui is menaced by plague more than for many years. We are distinctly apprehensive of the situation on Maui. Plans for the next two years have been laid. We have asked the legislature for an appropriation of $62,000 for the biennium to handle the problem on Maui.The work will be under the charge of Dr. Eskey. Here in Honolulu there has been an examination of rodents since plague infection was discovered. Until

recently that has been under the direction of the Public Health Service. Dr. Eskey has taken charge of it. We can very safely say no plague infection exists on Oahu.

Plans for this work, this plague campaign, require examination of all arriving ships.That is being done today by one of Dr.Grubbs' force. I might mention here that Dr. Grubbs is the father of the rat proofing of ships. It was known for many years that rats carried plague and disease, and it was thought there was no remedy for rats. Dr. Grubbs thought rat proofing of ships could be done on a large scale. He will probably tell you of it later.

The next step is inspection of outgoing freight in order to see that this freight is not of such a character as to allow rats to nest there. The next step is the regular inspection of wharves to see they are kept in proper condition. Everything on the wharf of a moveable nature is moved every seven days. Also Dr. Grubbs and I have been very active after the Harbor Commission here, to remove all double walls, etc., on wharves where rats might find a nesting place. By the way, the work on the Hilo wharg has been authorized today.Also shrubs and buildings adjacent to the wharves, all ground around wharves -- this area will be trapped and poisoned.

Now, only through this intensive campaign that I have outlined shall we cope with the situation. I am quite sure with this campaign effort plague elimination can be accomplished.

Of course I think it is an academic question whether plague has existed on Maui for 30 years. Deaths occurred,but doctors did not recognize the symptoms. Or whether this is a new infection, which, however, would hardly take place only in the Kula District, far from the coast. So I say it is an academic question. We know Maui is an agricultural and farming section. Makawao, until pineapples came, might have been full of undisturbed rats. Then the soil was stirred up, and the rats disturbed. There was so much chance for plague. -- I do not want to take too much time.

Chairman: I have a fear that the next speaker may plunge into a more complicated discussion of the problem right away. I might just review the subject.

Plague is primarily a disease of rats. Man gets it secondarily through fleas. The fleas live on the rats, and when leaving the dying rat generally strive to get on another rat,but they might occasionally get on a person and give him the disease.

We used to speak of the flea in general,but a few years ago we discovered differences in fleas.That problem has been under investigation a great deal, especially in the last ten years. More and more facts have been collected. The Public Health Service of course helps the States and territories at their request,and plague is one of the things we have been requested to help with. The Public Health Service also helps other countries. South America had a good deal of plague, and at the Pan-American Conference in 1926, I believe, the delegates became very much interested in the plague question. The upshot was that Dr. Eskey was sent down,and when he left Equador, Guayaquil had no plague, although it had been there a great many years. So far as I know there has been no plague there since. Dr. Eskey then came over here, and has been studying the problem here for a year. It is a long, long fight, and there is no use starting it before getting the facts. His subject is "Research Now in Progress in the Hawaiian Islands on Plague Transmission And What It Is Hoped Will Be Learned from this Study."

Dr. Eskey: During the past year the U. S. Public Health Service, with the cooperation of the Territorial Board of Health,has been conducting

an epidemiological study of bubonic plague in these islands. As plague is primarily a disease of rodents, and is spread through the agency of fleas, this investigation has been chiefly directed towards collecting data on the different species of rats, and the kind of fleas found on them. During the year, twenty thousand rats, and approximately sixty thousand fleas recovered from them,have been classified at the four laboratories situated at Honolulu, Kahului, Hilo, and Honokaa.

Four species of rats were found,three of which are common to nearly all parts of the world. The fourth, R.hawaiiensis, is a species native to these islands,although it is nearly, if not exactly, identical with rats found in other south sea islands, and R. concolor of Asia.

Seven species of fleas were classified, two of which are of particular interest, because they are probably the only ones that play any part in the transmission of plague. One of these Xenopsylla cheopis, is found in practically all parts of the world where plague has occurred while the other, Xenopsylla hawaiiensis, is peculiar to the Hawaiian Islands, although very closely related to somewhat similar fleas found in Australia and Java.The original host of this flea was Rattus hawaiiensis, but it is now found on all species of rats.In the Hamakua district of Hawaii it is present in large numbers on the Norway rat.

The most striking difference noticed between the two species of Xenopsylla, was in their distribution. The common plague flea, or X. cheopis,was found to be most abundant on rats caught in or under buildings, or within a few feet of them. Rats caught over three or four hundred feet away from buildings were practically free from this flea. On the other hand, Xenopsylla hawaiiensis was rarely found on rats caught in or close to buildings.In other words,one species.X. cheopis, is a house flea, and the other, X. hawaiiensis, is a field flea.

In this regard, I might mention that rat proofing of buildings not only keeps out rodents, but will also reduce the number of plague-spreading fleas in a community. An example of such a reduction in the house plague fleas due to reduced rat harborage in buildings was observed in the data collected from the Hamakua district, where the index of these fleas was much lower than in any other part of the islands. In the number of plague fleas per rat caught in a building averaged seven to eight, which is a very high figure, and indicates that plague would spread rapidly in Honolulu if it became infected again.

There was a very unusual distribution of X. hawaiiensis, or the field flea, in different localities of the islands.Not a single specimen was collected in Honolulu, only seven were found on eighteen hundred rats caught at Aiea and other parts of Honolulu Plantation, and 32 were found on a thousand rats from Waipahu. On the other side of the Pali it was found to be quite common,over three hundred being collected from about six hundred rats.In the region extending from Laupahoehoe to Hilo, where rainfall is excessive, only slightly over one hundred were found on three thousand rats. In the Hamakua district of Hawaii, more X. hawaiiensis were found than any other species of flea, and they outnumbered the common plague flea two to one. In the Makawao district of Maui, X.cheopis outnumbered X. hawaiiensis, but in certain sections the latter species was found in large numbers.

A study of the incidence of plague in the islands, shows that at Honolulu, Aiea, Waipahu, Hilo, and nearby places, where X. hawaiiensis is rarely encountered,the disease died out in a relatively short time. In the Hamakua district,where this flea is common,there have not been many human cases, but the disease has persisted for twenty-three years and has shown no sign of a spontaneous disappearance, -- a condition due to a reservoir of infection among the field rats which it has been impossible to control. There is little doubt but that the flea X. hawaiiensis is responsible for the persistent infection in the Hamakua

district. Rural plague as now present in the Makawao section of Maui is, in all probability, also due to the presence of this flea.

The biological characteristics of both species of Xenopsylla as determined by such studies as we attempted at the laboratory gave very similar results.

The female lays from four to seven eggs at one time, and larvae appear in about four days. Mature females appear from twenty-seven to thirty-three days after eggs are laid, and males usually not until seven to ten days later.

We were able to raise both species from eggs in test tubes, using green grass, barley, and dried blood for feeding the larvae. The Hawaiian fleas developed better in this manner than when raised in jars with white rats.

The life of the Hawaiian flea was much shorter than that of X. cheopis when kept on white rats in jars. This finding was in line with those in nature, as the results of the survey indicate that the Hawaiian fleas must disappear very rapidly from rats that leave the fields to reside in buildings.

The life of fleas collected from wild rats and starved is about the same for both species, averaging about six days for females and four for males.

Both kinds may live over six months when kept in test tubes and fed regularly on human blood.

The human reaction to the bite of both species is the same. The bite is painless and is followed by a small red blotch which disappears in three or four hours. In only two instances out of twenty different people bitten did any itching follow the bites.

I did not intend to say much about poison, but Mr. Pemberton mentioned it. I found in the work here that rats are very temperamental in the selection of food. For instance, of three rats of the same species kept in separate cages, one eats only barley, the second only rice, and the third only wheat. That is to say, they will pick out the baits that contain these grains, so that any poisoning campaign, to be most effective, should vary the baits used, -- first one cereal and then another. Raw bacon and grated cocoanut, added to cereals, make especially good baits. Also the fruit of the prickly pear. The Hawaiian rat likes meat pretty well, and so does the Norway rat. All like grains. Rattus rattus and Rattus alexandrinus prefer fruits. I cannot go into this subject, but by applying these principles I think we have devised many variations of bait, which we are using on Maui now. Last month we spread over 700,000 poison torpedoes there, and I expect to increase that to 2,000,000 a month in July when we get going full force.

Chairman: Thank you.

Mr. Ehrhorn: Have you ever tried KRO?

Dr. Eskey: Yes. I killed my rats afterwards with something else.

Mr. Ehrhorn: In Manoa Valley we fixed it with meat, and the rats disappeared. Is it a virus?

Dr. Eskey: It did not even make mine sick. The product must be fresh. This you get on the market is old. I only bought one can.

Mr. Ehrhorn: I have had experience in my own home, and they certainly disappeared. They are now coming back again, but very slowly.

Dr. Eskey: Well, meat is very good. I am timid about using meat, very, in a big poison campaign, because you will have dogs and cats and mongooses eating it.

Mr. Ehrhorn: On the can it says dogs and cats are not affected by it.

Dr. Eskey: The reason for that (as given by the Department of Agriculture) is that it is such awful tasting stuff other animals will not eat it. And if they do it makes them sick. They vomit. The rats do not vomit.

Chairman: The plague in the United States has usually been concentrated in ports and large cities, and one of the first measures against it is the building of rat proof houses. Now, when enforced rat proofing is done, it is very expensive. In New Orleans in the first year of the plague, the property owners were required to spend a vast amount of money, some seven million dollars, I understand. Rat proofing of houses is a great advantage outside of any question of plague, so if some simple, inexpensive method of doing it when the house is built is carried out, it is like insurance and pays as it goes. Health officials look forward to interesting business men in the proposition, and through them, the people building homes. We have here tonight Mr. B. W. Griffitts, president of Commonwealth Homes, Ltd., who will tell us about the value of rat proofing to the home builder as a selling argument.

Mr. Griffitts: Mr. Chairman, ladies and gentlemen: Needless to say we feel quite gratified that precaution against rat infestation which we are following, in the erection of our homes, has attracted the attention of Dr. Grubbs.

In my fifteen years experience in home building we have learned many practical things regarding rats, and what we might expect from clients if we build homes which later on will become infested.

One of the benefits of our present economic depression is the fact that it is bringing America back home. Families are spending more time in their homes, thereby becoming more interested in their comforts and conveniences.

In the past all too few of our home buyers looked under the house or in the attic, but due to a broadening knowledge of sound construction the number is rapidly increasing of those individuals seeking the foremost in advanced construction.

Buyers of homes are impressed first with their beauty and convenience, which broadly speaking covers architecture, room arrangement, type of bath room, plumbing and lighting fixtures, kitchen cabinets, etc., but these factors are valueless today, unless backed up by sound construction and so marked has become the popular demand on the mainland for rat resistent structures that in many states they are considering passing state legislation, covering this phase of construction work which does not add five cents in cost if done at the time of construction.

The day is past when home buyers are satisfied with the type construction which makes the building obsolete and possessed of low resale value within a comparatively few years. The entrance of rats and mice is one of the greatest factors in deterioration of a home. Every home should be reasonably rat proofed, if only for its future sales value from this sanitary precaution.

I can definitely state that any home that is reasonably rat proofed will not only carry a greater resale valuation, but I believe that if a little of the money being spent in remodeling of investment dwellings was spent for rat proofing so that the tenant could be assured of reasonable protection against rats and mice they would have a larger rental

value.

The national publicity that is being given the subject of rat proofing of homes is not only timely, but worthy of the attention of every citizen of Hawaii, and a word of mouth campaign should be carried on among home owners regarding the precaution they should take, to keep rats from their homes. They should watch where they place their garbage cans, keep the screened ventilation windows under the house closed at all times.

We can legislate for certain standards, and we can build according to certain standards,but after that is done it is up to the home owner himself to use ordinary precaution. I would suggest a six months inspection of every home by the home owner.

One of the first questions that is put to us at present by the prospective home builders is regarding their rat resistent quality. This education on the part of the public is very recent, and is due in a large measure to the educational work carried on by governmental agencies along these lines. Thank you.

Chairman: Thank you, Mr. Griffitts. I am glad you have emphasized the point that rat proofing, like cleanliness, must be kept up to be efficient.

I now come to my own subject, rat proofing on land and sea. It is such a large subject, that I shall spend most of my time showing the models which are here on exhibition. I hope you will look at them more in detail after the talk is over. I will pass around some mimeographed sheets on which are given the principal facts, regarding rats and certain limitations on their ability, which are the basis of rat proofing both on ships and in buildings.

"DATA FOR USE IN RAT PROOFING

Rats of the Hawaiian Islands

Norvegious (gray or sewer rat): Body 9 inches, tail eight. Brown gray. Poor climber. Burrows.
Hawaiiensis (Hawaiian rat): Body 5½ inches, tail six. Brown gray. Burrows and climbs.
Alexandrinus (roof rat): Body 7½ inches, tail nine. Brown gray, lighter belly. Climbs, sometimes burrows.
Rattus (black rat): Body 7 inches, tail eight and one half. Black. Climbs, sometimes burrows.

Limits of rat activities used as a basis of rat proofing

Rats will not burrow to a depth of 2 feet in the ground. In some soils not over 18 inches.
They cannot climb a vertical surface if perfectly smooth.
They cannot crawl on the under side of a horizontal surface.
They cannot swing around an obstruction if the reach is 9 inches.
They cannot jump to a point three feet above them.
They will rarely gnaw unless they have a firm support on which they can stand on all four legs.
They usually gnaw in an angle or corner.
They cannot gnaw through concrete, or any metal used in buildings except lead.

The necessities for rat life

(1) Food and drink (2) Hiding and nesting places

To deprive them of these:

1. All food stuffs,new or garbage, should be kept in rat-proof containers, or rooms. That is, rooms devoid of rat harbors and into which rats cannot come.
2. All small inclosed spaces should be either abolished, or blocked off by material impermeable to rats, at all points where a rat may get a foothold in order to gnaw through.
3. Large openings should be closed by screening,or by doors or win-

dows that fit and that are impermeable to rats at gnawing levels. These should be kept closed by springs or other mechanical means. Small openings should be permanently closed.

What a Rat Proof Building Is

A rat proof building is one in which it is impossible or difficult for a rat to hide, nest or move about in the building itself. This condition is attained by leaving no dead spaces when the building is constructed, or by abolishing them or blocking them off by material impervious to rats.

Rats may enter such a building, but they will find no permanent or secure hiding place. They cannot move about except in the open, and their food supply will be limited. In other words, they will be confronted with an acute housing problem, high cost of living, and poor transportation between home and business (food getting)."

The rat proofing of buildings was developed some 30 years ago as an anti-plague measure. About ten years ago we began to apply rat proofing to ships, and this has been quite completely worked out. Although a more recent development, it has been found that a ship can be rat proofed even better than a house. This is because a ship is more valuable and costs more money as a rule, than a building, and the reward for being free from rats is greater because the cargo is protected from the damage that rats so frequently do, and in addition the expense and delay incident to fumigation are to a large extent avoided. Business men engaged in shipping have been quick to see the advantage of having ships free from rats, and have been willing to spend money if this can be accomplished. It has been shown that if rat proofing is incorporated in the original plans for construction of the ship, there is very little additional cost. At present all the ships built by the principal mercantile nations are rat proof.

This is true of all the large ships now entering the port of Honolulu. Based on the work of the U. S. Public Health Service, the Bureau of Standards has made specific rules, and all ships built in whole or in part with money loaned by the United States government must be constructed according to these standards.

The small models that you are examining were made partly to work out methods of rat proofing on ships and partly for demonstration purposes. A few years ago we had to resort to propaganda to show how rats could be excluded from ships by eliminating small inclosed spaces where rats could harbor and by protecting food stuffs. This propaganda is no longer necessary, and the principles of rat proofing are understood by all the great ship builders of the world, and the old quarantine rules that caused considerable delay and expense have been modified and entirely rescinded for ships that are rat proof and maintained free from rats.

Of course the word "rat proof" is an exaggeration. A rat can get on a rat proof ship, and it can enter a rat proof house, by the same avenues of approach that a human being can get on a ship or in a house, but once on the ship or in the house the rat will find no hiding places or anything to his liking, and will either leave or die.

The type of construction of buildings is changing practically all the time, so no attempt has yet been made to standardize rat proofing for buildings. However, the principles which I have given you on the mimeographed sheets may be applied to almost any form of construction.

In some instances laws requiring rat proof houses have been passed, but this is advisable only when plague exists. It is better to educate the house builder and the home owner so that they will see that the principles of rat proofing are applied to their own property. Such action will bring its own reward, in freedom from the annoyance of having rats about the place, and, as has been said, in the resale value of the house.

This model which I show you now is a section of a warehouse designed to store grain or anything that is rat food. It is entirely open, but is three feet from the ground, and there is a protecting ledge of at least nine inches on all sides. As a rat cannot jump three feet vertically in the air, and cannot reach nine inches in order to swing around this ledge, he cannot get into the house. Of course there must be no steps or anything like it to make the distance less than three feet from the ground to this loading platform. If a man wants to get into the warehouse, he can sit down on the platform and swing his feet up on it. Trucks back up to this platform to load or discharge their cargo. You will note that the electric wires come in through the floor, or if they must be put overhead they have rat guards on them. You will also note that there is a false drain in the floor. This is a pipe four or five inches in diameter. If an occasional rat gets in with the cargo, he will hunt this out as a nesting place and can be drowned out at intervals.

The second model is another type of warehouse that is built on the ground. The floor is concrete with a surrounding wall extending 18 inches into the ground and 12 inches above the floor. Rats cannot burrow under this floor and cannot reach above the 12 inch wall and gnaw through even if the walls above are of wood.

The third model shows different methods of blocking double walls so that rats cannot come up from beneath and get into the walls. The first section shows how easily rats can gain access if blocking is neglected. The second section shows blocking by wood, but is not as efficient as if made with cinders and concrete, bricks, or ordinary concrete.

The fourth model is sections of a house such as Mr. Griffitts is putting up in Honolulu. This is what may be called practical rat proofing. It would not answer some of the most stringent laws, but I do not believe anyone would be troubled with rats in such a house. The concrete foundation extends 12 inches into the ground, but if a rat should burrow beneath this he would find nothing to attract him on the other side. On the outside there is reinforced concrete stucco. On the inside there is concrete plaster. The double walls are blocked off at regular intervals by wood which it would be very difficult for a rat to gnaw through especially as he has no secure place to stand. The tiled roof is set in concrete. The ventilators beneath the air space under the roof are screened. All other openings leading into the air space below the roof are either screened or completely closed with concrete stucco. All openings both through the foundation and into the air spaces should be screened with one-half-inch 12-guage wire screening. This will not rust out for a long time, and small boys cannot break it by punching sticks through it.

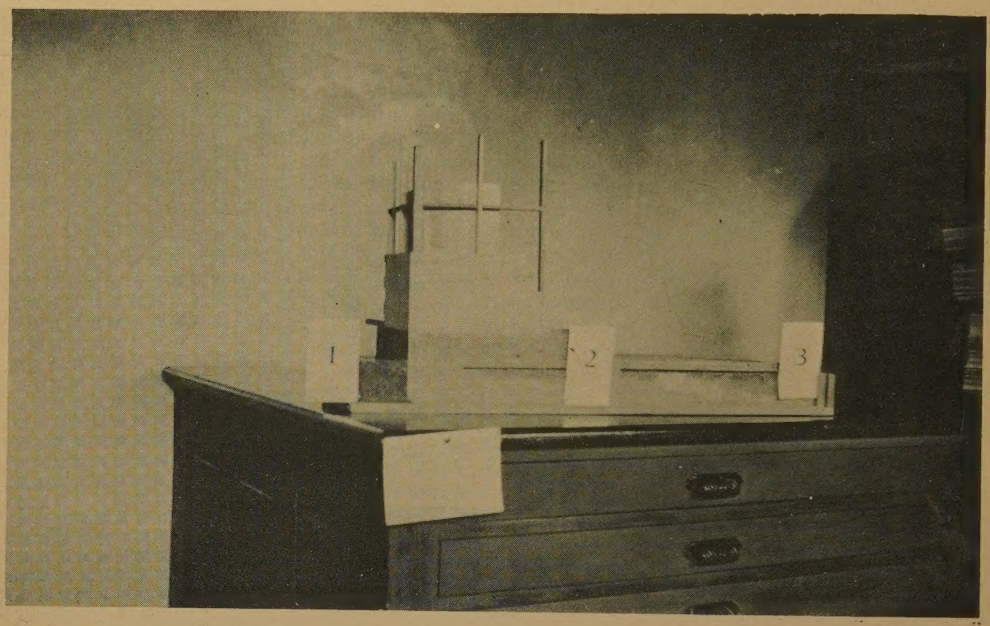
If there are any questions, surely the various speakers will answer.

Mr. Moe: If we find a flea are we exposed to the plague?

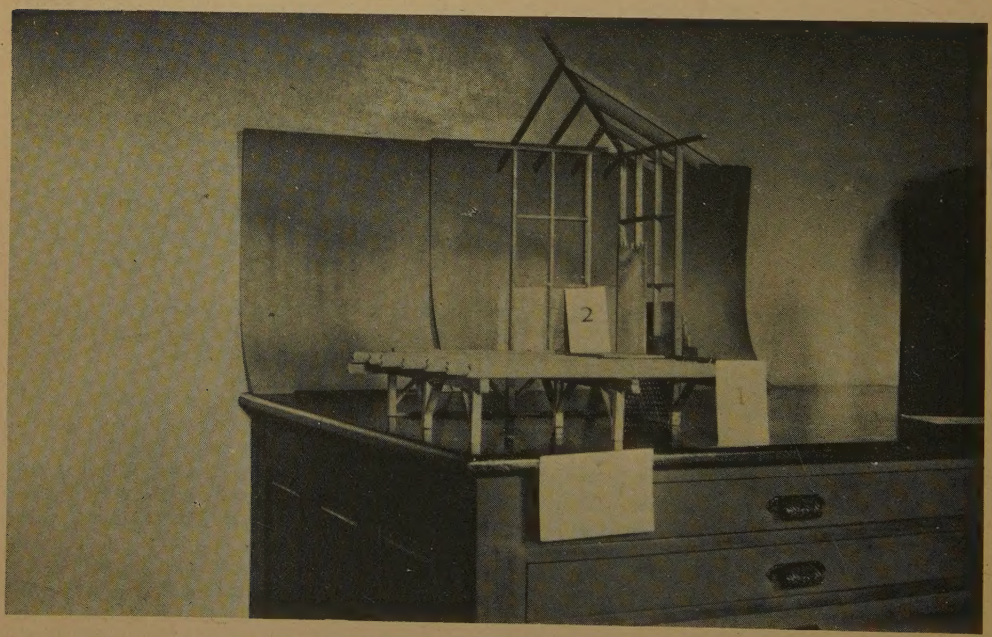
Dr. Eskey: What kind of flea? The most common flea that attacks people is the dog flea. It is very rarely dangerous. The pulex irritans, the human flea, is responsible for transmitting plague between people. It is quite common here in the Islands. These do not attack rats very much. This flea is not dangerous unless you are where there is plague. There is some question about how long a plague infected flea lives. It is like the mosquito in that respect, with malaria.

Mr. Baker: I would like to hear about the plague organism.

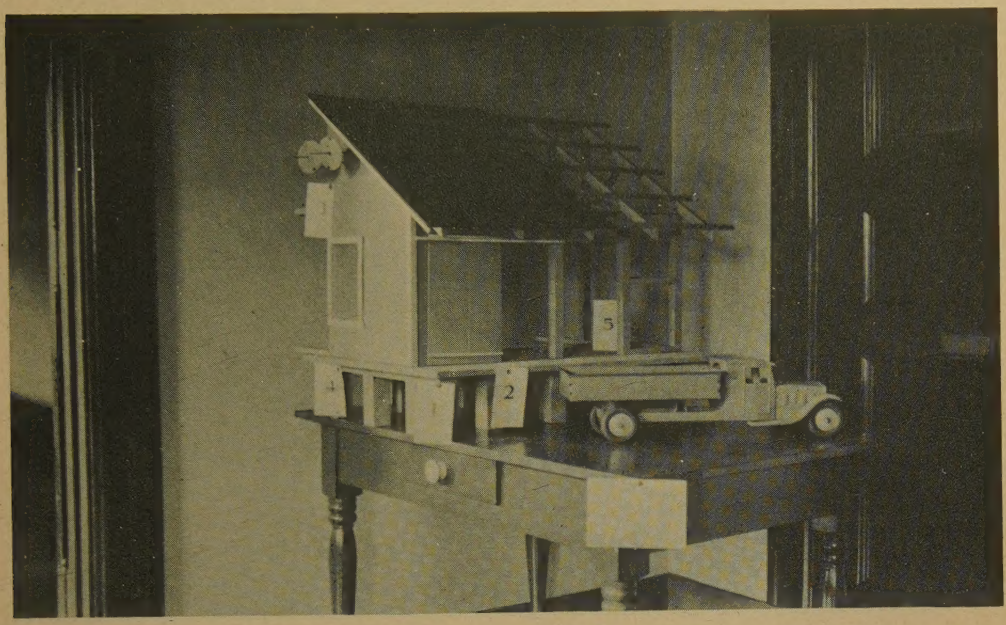
Dr. Eskey: The plague is a bacillus, a bacteria. It does not develop outside the animal tissue. It soon dies when exposed to the air. In the infected flea, the organism closes, plugs up the stomach. When the flea tries to take blood from an animal, the stomach regurgitates.

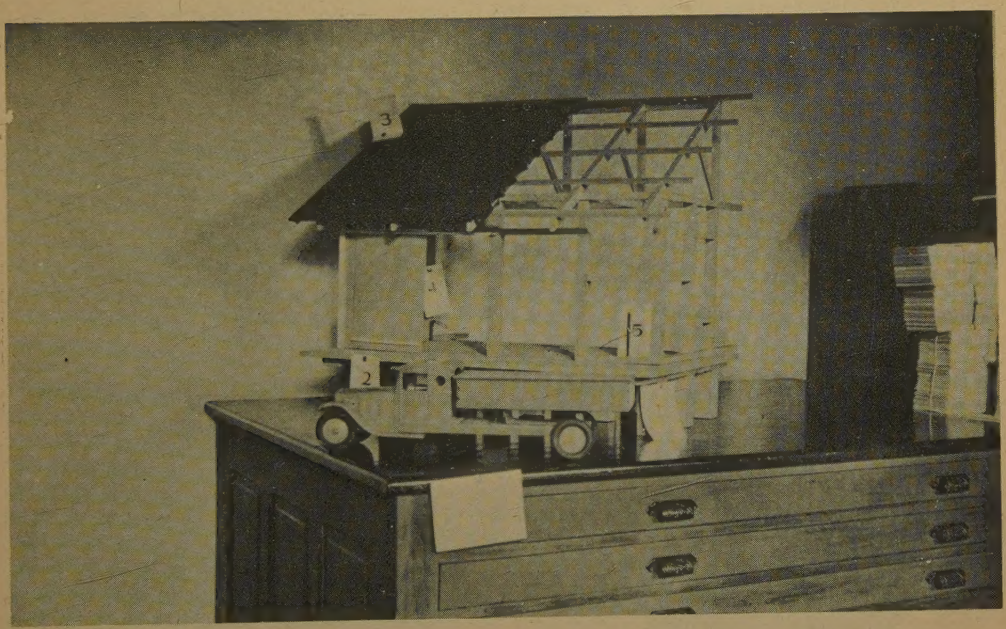


Section of rat proof warehouse on the ground shows (1) concrete wall extending 18 inches below the surface; (2) concrete wall extending 12 inches above the concrete floor;(3) concrete floor without wall, which makes a good rat harborage.

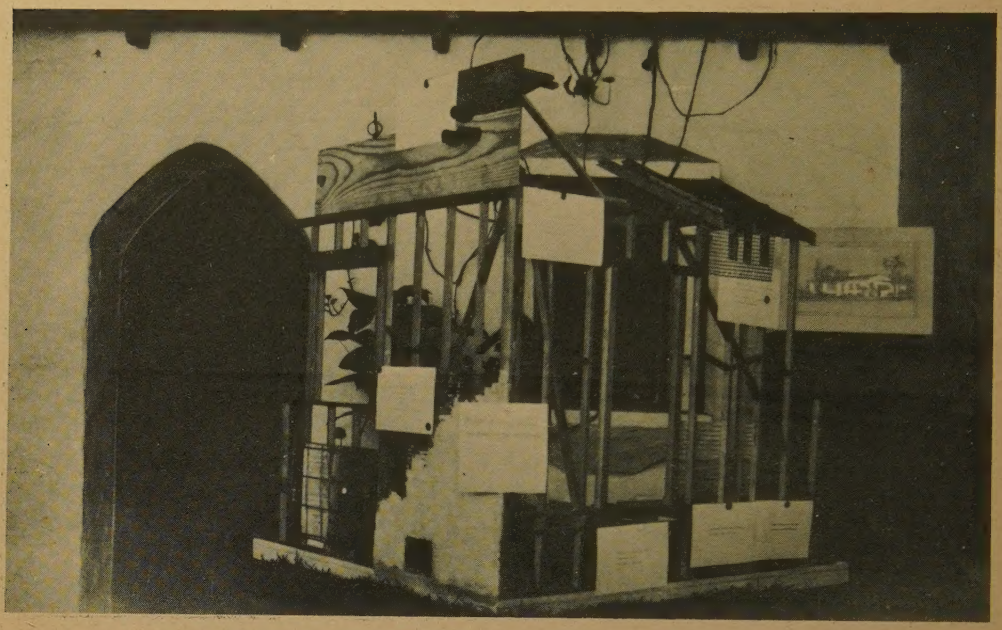


Section of cheap wooden construction, rat proofed (1) by elevation, (2) by flashing double walls and by fire stops.

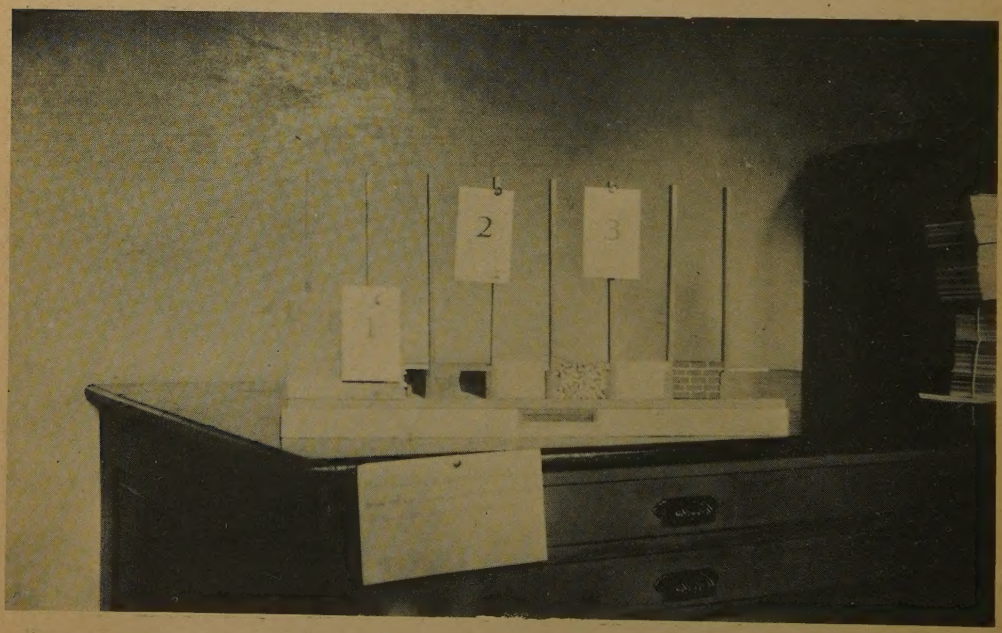




Two views of front section of a rat proof warehouse for storage of grain or similar merchandise. (1) Shows height of floor 3 feet above the ground, with no steps. Rats cannot jump 3 feet vertically. (2) Overhang of 9 inches on all sides. Rats cannot reach 9 inches in order to swing around an obstruction. (3) Overhead light or telephone wires have rat guards. (4) Same wires preferably introduced through the floor. (5) False drain 5 or 6 inches in diameter, which will be used for a harborage by any stray rats that get in the cargo. This false drain can be filled with water to drown the rats.



Model of section of type of practical rat proof residence being constructed in Honolulu. Cement stucco outside; concrete plaster inside; all openings below floor and above ceiling screened; space between double walls blocked for rat and fire prevention.



Model showing how rats may enter space between double walls and methods of preventing this. (1) Entrance to double wall from below, not stopped. (2) Stopped by wood. (3) Stopped respectively by sheet iron, by cinder concrete, by concrete, and by bricks. The last three are preferable.